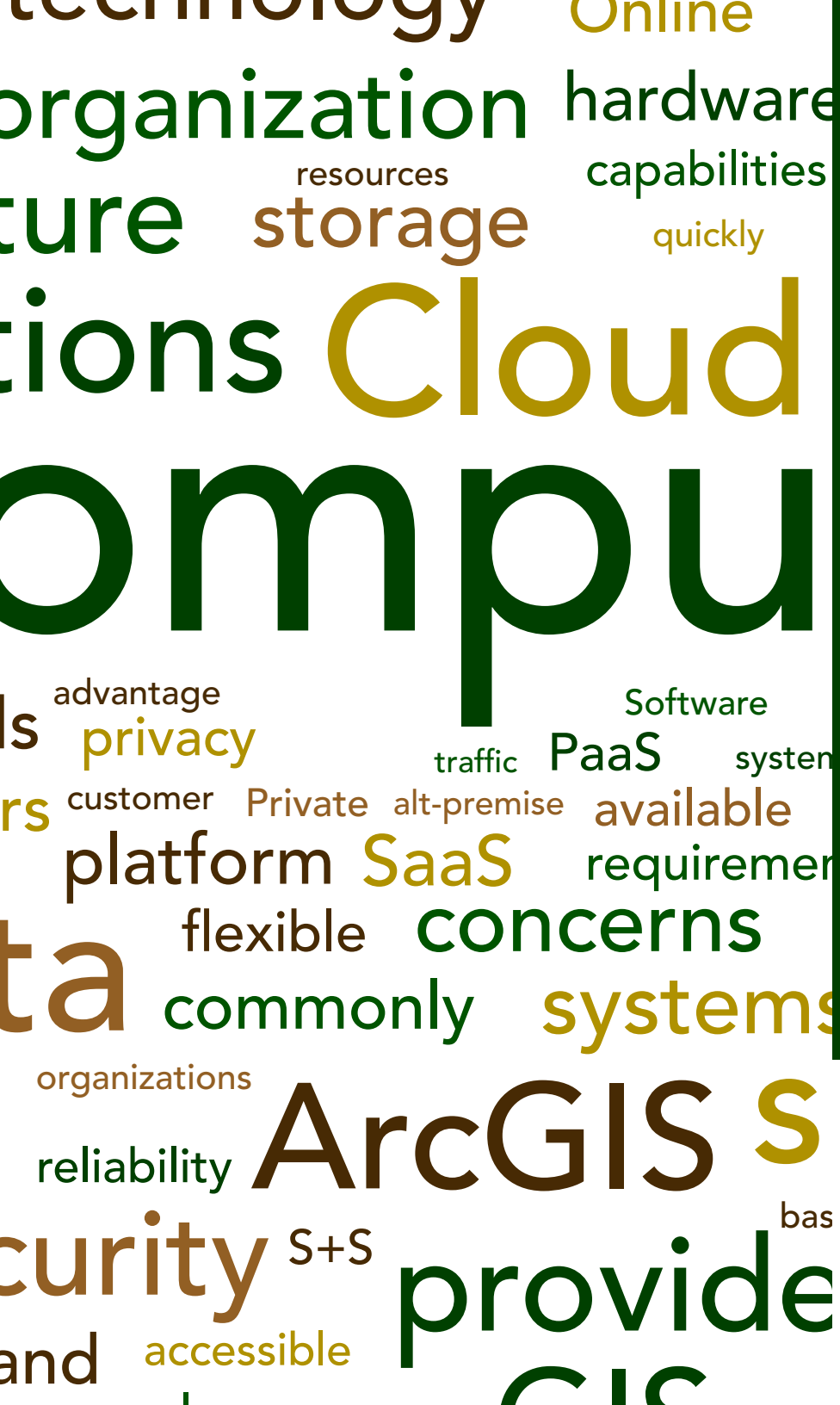

GIS in the Cloud

The New Age of Cloud Computing and Geographic Information Systems

By Victoria Kouyoumjian, Esri IT Strategies Architect

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Introduction

Cloud computing is rapidly emerging as a technology trend that almost every industry that provides or consumes software, hardware, and infrastructure can leverage. The technology and architecture that cloud service and deployment models offer are key areas of research and development for geographic information system (GIS) technology.

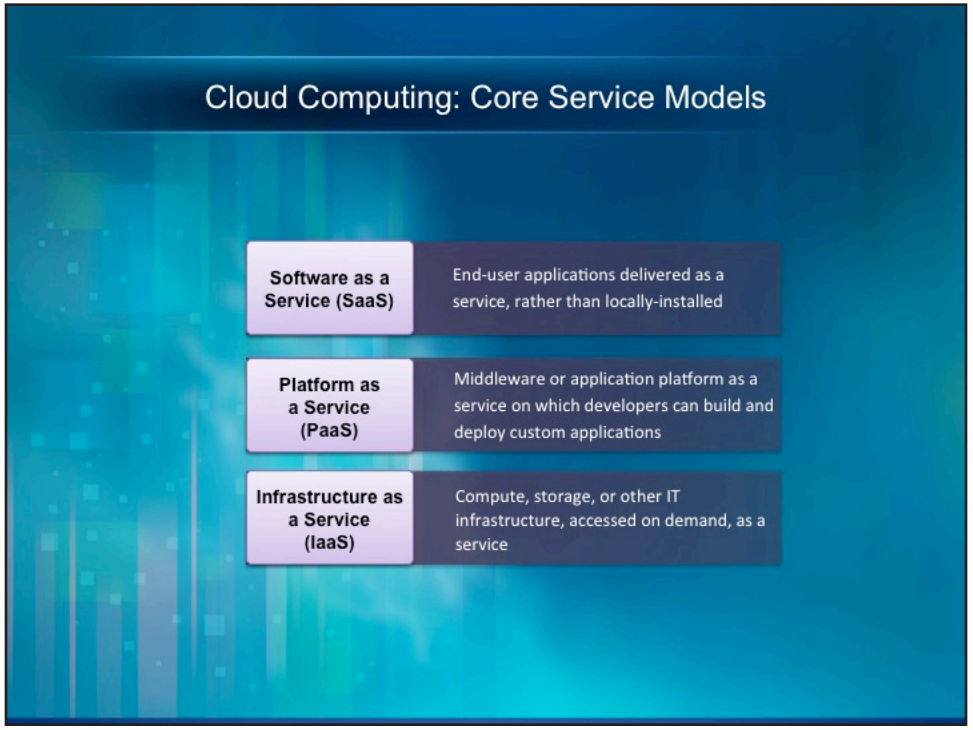
What Is Cloud Computing?

Although there are several variations on the definition of cloud computing, some basic tenets characterize this emerging environment. Cloud computing furnishes technological capabilities—commonly maintained off premises—that are delivered on demand as a service via standard Internet protocols. For public cloud services, since a third party provides access to the applications and infrastructure, consumers of public cloud services do not own the assets in this cloud model but instead pay for them on a per-use basis. In essence, they are renting the physical infrastructure and applications within a shared architecture. Cloud offerings can range from data storage to end-user web applications to other focused computing services.

One critical difference between traditional and cloud computing is the scalable and elastic nature cloud computing provides. Instead of a static system architecture, cloud computing supports the ability to dynamically scale up and quickly scale down, offering cloud consumers high reliability, quick response times, and the flexibility to handle unpredictable traffic fluctuations and sporadic demand. Cloud computing also supports multitenancy, providing systems configured in such a way that they can be pooled and shared by many organizations or individuals. Virtualization technology allows cloud vendors to convert one server into many virtual machines, thereby eliminating client-server computing with single-purpose systems. This maximizes hardware capacity and allows customers to leverage economies of scale.

Cloud Service Models

Three core options compose the service models within the cloud computing environment.



Each service category can be leveraged independently or consumed in combination with other service tiers.

Software as a Service (SaaS) comprises end-user applications delivered as a service rather than as traditionally installed, on-premises software. The most commonly referenced example of SaaS is Salesforce.com, which provides

a customer relationship management (CRM) system accessible via the Internet.

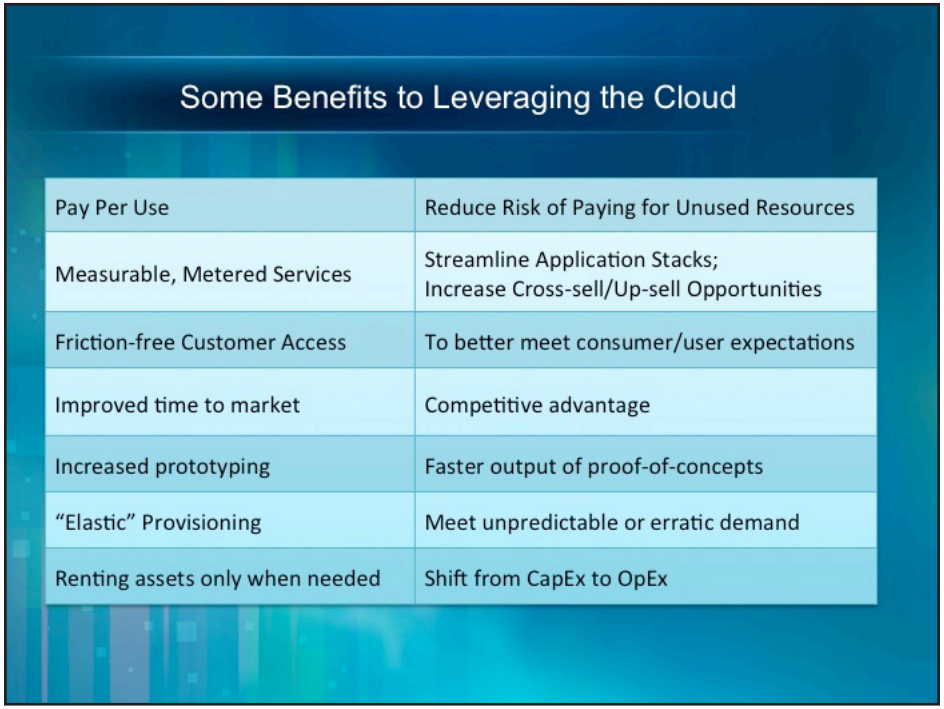
Platform as a Service (PaaS) provides an application platform, or middleware, as a service on which developers can build and deploy custom applications. Common solutions provided in this tier range from APIs and tools to database and business process management systems to security integration, allowing developers to build applications and run them on the infrastructure that the cloud vendor owns and maintains. Microsoft's Windows Azure platform services are often referenced as PaaS solutions at this middleware tier.

Infrastructure as a Service (IaaS) primarily encompasses the hardware and technology for computing power, storage, operating systems, or other infrastructure, delivered as off-premises, on-demand services rather than as dedicated, on-site resources. Examples include Amazon Elastic Compute Cloud (EC2) and Rackspace, among many others.

Cloud Benefits

Cloud computing provides opportunities for organizations to become more cost-effective, productive, and flexible to rapidly deliver new capabilities.

The pay-as-you-go pricing model is often quite flexible when renting cloud applications or infrastructure, allowing prospective cloud clients to "try before they buy," while existing cloud consumers can pay in advance to take advantage of volume discounts and satisfy budget forecasting requirements. Renting assets shifts the duty of maintaining on-premises data centers to the cloud vendor, alleviating the customer's responsibility for software and hardware maintenance, ongoing operation, and support.



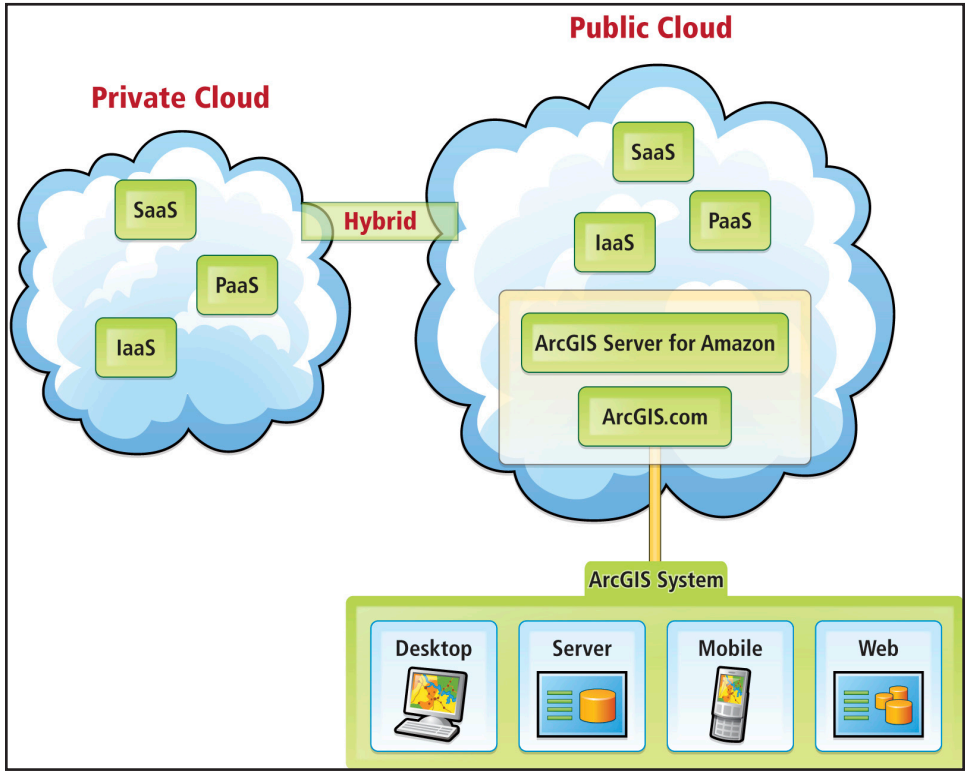
Ideally, cloud adopters should be confident that they are consuming state-of-the-art systems that are highly reliable and flexible enough to handle large traffic fluctuations. The burden, then, is on the vendor to scale and continually reinvest in the on-demand IT architecture and service so that consumers are consistently provided with a robust, updated solution.

Moving parts of the corporate data and computing center to the cloud also reduces the amount of fragmented infrastructure, driving down up-front capital spending. As monies are reallocated to be invested in core business, other initiatives could be launched to provide direct value to customers and employees, giving the organization a competitive advantage.

With increasing outsourcing and offshoring, leading to the creation of a global workforce, team productivity depends on the power of networks and the Internet as a common platform. As such, cloud services are available 24/7, accessible from any browser on any device regardless of time zone. This provides faster, easier access for workers to do their jobs, allowing competitive differentiation for the organization and, likewise, retaining and attracting valuable and talented staff.

Public versus Private Cloud

There are several types of cloud computing deployment scenarios. The National Institute of Standards and Technology (NIST) is emerging as the preferred provider of the de facto definition of cloud computing and the distribution models, seen here with some Esri examples.



Some organizations, concerned about security, may opt for a private cloud or a hybrid deployment model.

Public Cloud The public cloud is what is most commonly being referred to when discussing cloud computing, where the infrastructure and applications are owned by the organization selling cloud services.

Private Cloud Since many traditional vendors and users are not quite ready to jump into public cloud computing or are restricted from doing so, the cloud service tiers are replicated within a private cloud environment, behind the firewall, on-premises, and maintained within the parameters of the host organization.

Hybrid Cloud Many believe that the sweet spot for cost optimization in an organization will be found in a delicate balance of public, or community, and private clouds.

Risks in the Cloud

Despite cloud computing's many benefits, it's important to be aware of the risks and concerns when doing business in a cloud architecture.

Security and privacy are two of IT professionals' top concerns when considering moving to the cloud as either a vendor, broker, or consumer. Typical security and privacy examples include data storage and transfer protection; vulnerability management and remediation; personnel, physical, and application security; data privacy; and identity management.

Depending on your industry, customer base, or public or private organization, compliance requirements must be met and secured. Some compliance concerns include business continuity and disaster recovery; security standards (ISO 27001); logs and audit trails (eDiscovery); and specific standards and governmental compliance requirements such as Sarbanes Oxley, Payment Card Industry (PCI), and the Health Insurance Portability and Accountability Act (HIPAA).

There are specific legal concerns when providing cloud services and, subsequently, consuming them. These revolve around liability and recourse, intellectual property issues and terms, as well as vendor transparency regarding location of recovery data centers. When relying on an Internet service, there is always a question of availability and the peak-load capacity that the vendor can carry. For example, current and prospective customers can scrutinize the uptime (and downtime) of Amazon Web Services and Google App Engine through CloudStatus.com to determine how healthy the services have been, monitoring their track record of service failures, latency, and throughput. There have been instances of outages, for instance, with

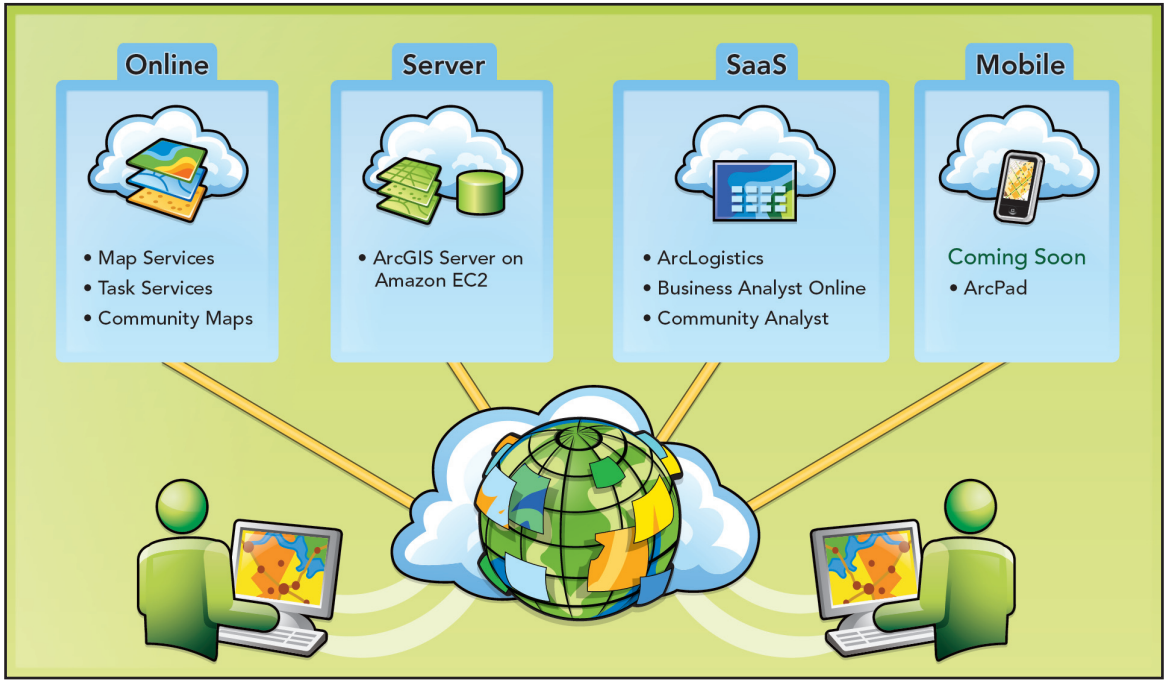
Amazon Web Services and Google, and they should serve as reminders to be vigilant and cautious in the on-demand marketplace.

Finally, as of yet, there are no standards to ensure interoperability or free movement between cloud providers. As such, cloud consumers should also be aware of vendor lock-in when moving forward in the cloud ecosystem.

When consuming cloud services, clearly it's important to recognize the potential hazards and risks ahead, as with any new or existing IT investment. Concerns about security, inquiries around the provider's maturation in an incubating industry, reliability, and regulatory issues are all topics for discussion and clarification in a service-level agreement (SLA). Although they are not a guarantee, to better ensure delivery of best practices in the cloud, SLAs with the cloud vendor are recommended when consuming cloud services. Realistically, these concerns are not too different from those that one would have choosing any third-party provider or service. As barriers to entry into cloud computing continue to fall away, confidence in cloud vendors will be established through repeated successful experiences, testimonials, and proven reliability with respect to operating procedures and performance.

ArcGIS and the Cloud

Esri considers cloud computing and technology important in the development and vision of the ArcGIS platform. Several options are available for companies that want to improve productivity and efficiency while reducing expenses and freeing up valuable IT resources to concentrate on newer business initiatives.



Cloud-based content, servers, and applications provide cost-effective and flexible opportunities for organizations to deliver and consume GIS content and services.

GIS services are available in the cloud so that ArcGIS users and developers can access ready-to-use maps including imagery, topography maps, and street basemaps as well as task services such as routing and geocoding

services for North America and Europe. For more information, visit ArcGIS Online.

ArcGIS Server can be deployed in the cloud via the Amazon EC2 so that organizations and developers can publish and quickly deploy custom GIS mapping applications within minutes. For more information, visit ArcGIS Server in the Cloud.

GIS Software as a Service provides focused, cloud-based clients and applications that easily solve complex business problems using GIS tools and data but don't require GIS expertise to use. For more information, visit ArcLogistics, Business Analyst Online (BAO), or Community Analyst.

More mobile GIS services are coming to the cloud soon so that an organization's field staff, business professionals, and consumers can access GIS capabilities and data using nearly any mobile device. For more information, visit ArcGIS Mobile.

With ArcPad, users can take advantage of the ArcGIS Server ArcPad extension to send edits back to the enterprise geodatabase directly from the field. Edits from ArcPad can be enabled on top of the ArcGIS Server on Amazon EC2 Amazon Machine Image (AMI), which is preconfigured with SQL Server Express. Optionally, if more space for your editable features is needed, ArcPad edits can be synchronized to the Enterprise Geodatabase AMI, also available with ArcGIS Server on Amazon EC2.

Esri has been providing Software plus Services (S+S) for some time, allowing customers to leverage their on-premises solutions with on-demand services. Esri's ArcGIS Online map and GIS services provide S+S users with immediate access to cartographically designed, seamless basemaps

to which they can easily add their own data in an Esri on-premises product. As a community cloud, the ArcGIS Online Content Sharing Program enables users and organizations to contribute geographic data content. Leveraging Amazon's EC2 and Simple Storage Service (S3) compute and storage services allows Esri to host the content and provide access 24/7. ArcGIS Explorer users can consume ready-to-use basemaps and layers from ArcGIS Online services in the S+S model. Also, ArcLogistics provides software and access to online services that help you create optimal vehicle routes and schedules.

As cloud computing continues to move farther into mainstream IT to become a convention in business, Esri will continue to offer solutions to allow customers and prospects success in the cloud.

Case Study

From Design to Deployment

ArcGIS 10 Apps in the Cloud

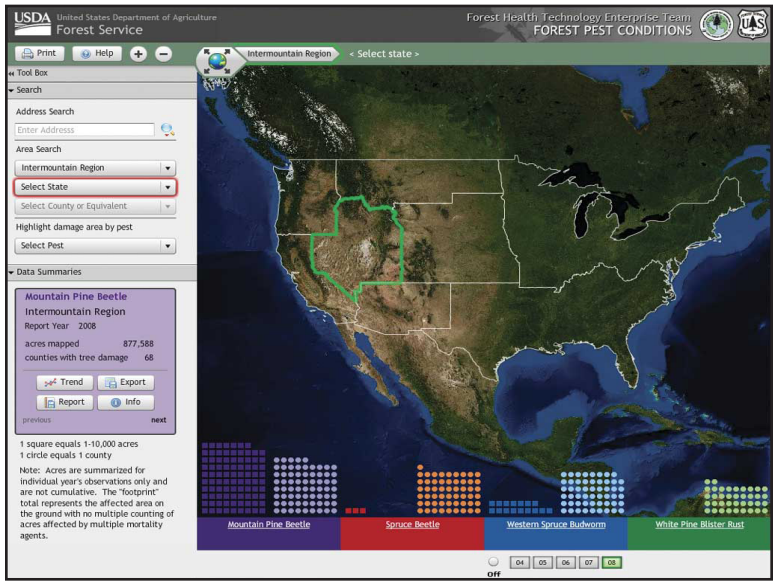
By Brian Noyle and Dave Bouwman, DTSAgile

Historically, the Forest Health Technology Enterprise Team (FHTET) has collected and analyzed data describing the effects of major forest pests on the landscape and disseminated this information through an annual hard-copy report. This article describes a custom application the team deployed to the cloud to make this information available to a wider audience.

While GIS and hard-copy maps play a role in the preparation of the FHTET report on the effects of major forest pests, this static report does not fully leverage the data exploration and analysis tools available from today's GeoWeb applications. A current software development initiative is using ArcGIS Server 10 and the Flex API to create a series of rich Internet applications (RIAs) facilitating the distribution of information on forest health to a variety of audiences. In addition, the FHTET team elected to use this initiative as a test bed for assessing the ease and speed with which custom applications can be deployed to the Amazon Web Services (AWS) cloud with ArcGIS 10 for greater scalability and convenience.

Given the richness of the FHTET data and the desire for novel user experience (UX) elements in the applications, FHTET has elected to pursue a fully custom web implementation based on Esri ArcGIS Server 10 and the Flex API with many custom widgets and extensions of the DynamicMapServiceLayer. We have based our implementation on our

considerable experience in customizing Esri's Flex Starter Kit to produce a template that will now serve as the starting point for many Flex-based applications leveraging ArcGIS Server 10.



Bar charts prominently displayed across the bottom of the map show the acreage and number of counties affected by each pest.

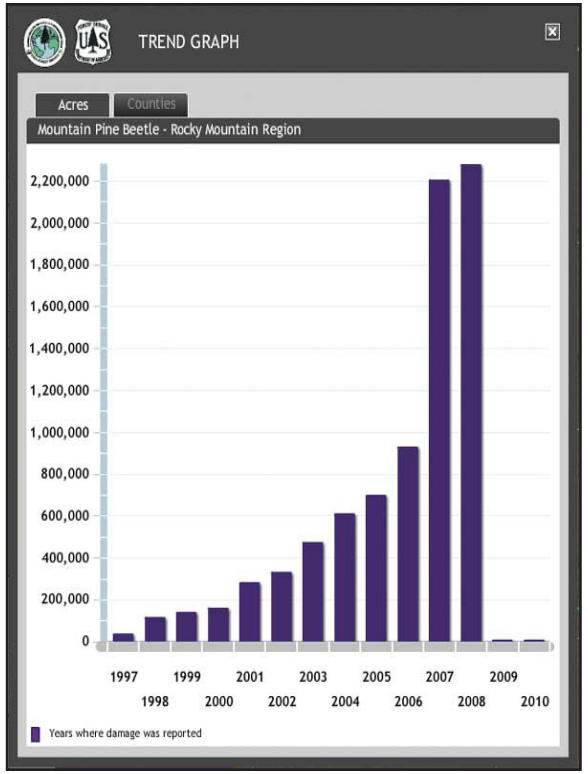
The Forest Pest Conditions Viewer

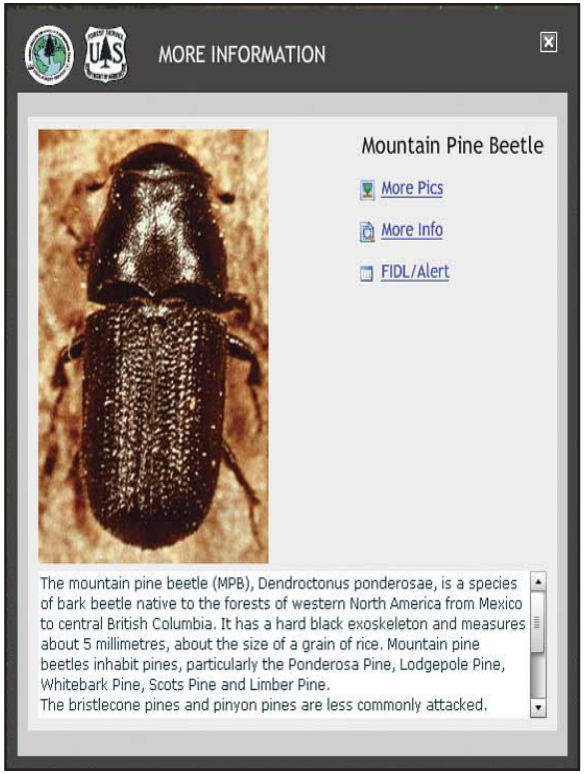
A FHTET Forest Pest Conditions Viewer public application (fhtet.dtsagile.com/fhtet/Flex/FPC#) was first developed to help public users explore the impact of many forest pests for different forest service regions. The quantities and types of pests displayed in the Flex application can be configured by each forest service region so that users can see the "top" pests for a given region, based on the decisions and experience of forest health professionals.

Because the application is designed primarily as a data exploration tool, only minimal interaction is required of the user. Once a region, state, or county is selected, the application makes a service call to get updated data as JSON and renders the results for the user. Region and county selection can be done on the map or from pick lists in the search pane located on the left side of the page. Bar charts prominently displayed across the bottom of the map show the acreage and number of counties affected by each pest. Data summaries and links to external information are also provided in the dockable left pane. A function that generates a chart showing pest damage trends for all years in the system is included in the tabular data summaries. Users can also view information on specific pests, generate preformatted pest reports, and export raw data in CSV format.

The Disturbance Mapper

In addition to the public data explorer, FHTET has deployed a secured Disturbance Mapper Application designed to use remotely sensed data for detecting the presence of pests in the landscape. The application is targeted at individuals who perform statewide and regional flight planning for aerial pest surveys. Its goal is optimizing flight planning and reducing total costs for aerial pest surveys by allowing planners to target areas of interest through map exploration in a web browser.





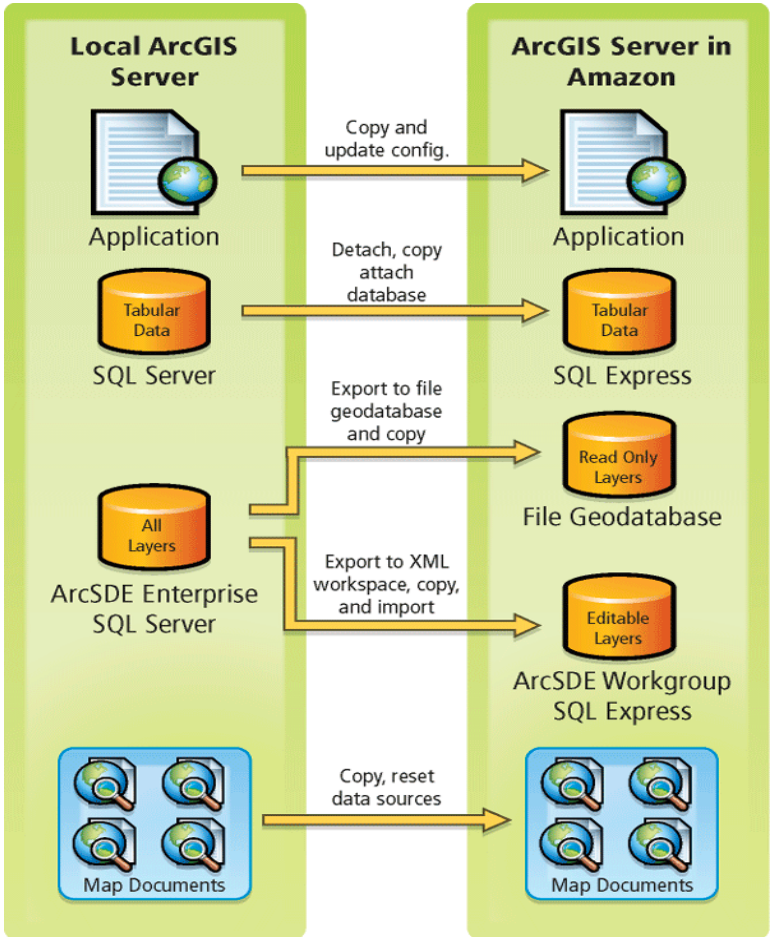
Pest incidence trend charts and information on individual pests are available from widgets in the FHTET public viewer.

Areas of interest for pest surveys are identified based on change detection data from Moderate Resolution Imaging Spectroradiometer (MODIS) preprocessed imagery. Custom map layer extensions for extending the DynamicMapServiceLayer have been implemented that allow flight planners to adjust threshold settings on the change detection imagery to view differences in forest green-up and senescence that signal the presence of tree stressors.

Migrating to the Cloud: It's as Easy as . . .

As this article was being written, Esri announced the availability of a cloud-based solution for ArcGIS Server. Based in the AWS cloud, this deployment option provides Amazon Machine Images (AMIs) preloaded with ArcGIS Server for Esri customers who want quick deployment, scalability, and flexibility in their GIS infrastructure.

What do we—as architects and developers—need to know to be ready to deploy our custom ArcGIS Server apps to the cloud? The first thing you need to know is that the process is just plain easy and will require just a few tweaks of your normal deployment patterns for custom apps built against ArcGIS Server. The accompanying diagram maps major system components in a typical example of an ArcGIS Server solution to major system components used in an ArcGIS Server 10/AWS cloud implementation.



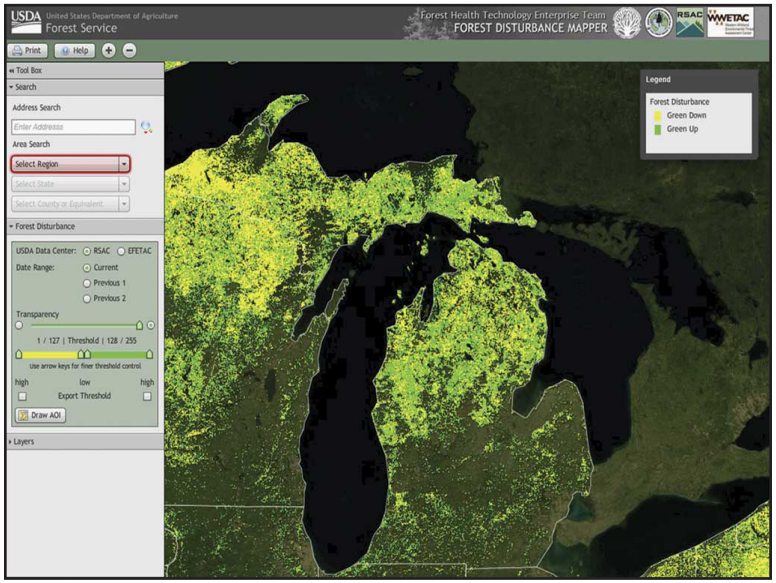
Migration of an On-Premises Application to the Cloud

Once an ArcGIS Server 10 AMI has been launched in the Amazon cloud and sufficient storage space has been purchased and configured, the deployment of an on-premises application to the cloud is very straightforward. After RDP-ing [i.e., using remote desktop protocol] to the

running AMI, the developer simply pulls in the deployed application (via FTP or using copy/paste for small items) and updates any configuration settings.

The DBMS instance (Microsoft SQL Server in our example) supporting the application is detached from the on-premises deployment database server, copied to the AMI, and reattached as a SQL Server Express instance (still well under the 4 GB size limit).

In our deployment of this application, we split our geodatabase into operational and base layers. Base layers that do not get edited are stored in a file geodatabase on the AMI, guaranteeing acceptable performance, while operational layers that are editable are stored in an instance of ArcSDE Workgroup on SQL Server Express.



Forest Disturbance Mapping Using Custom Map Layer Implementations

Finally, any map documents required to support the ArcGIS Server map services are copied to the AMI, and the data sources are reset to reflect the new data locations. It is really just that easy and straightforward.

What about That Data Thing?

Some readers may be asking themselves why our migration story splits a perfectly good enterprise geodatabase running against SQL Server into a file geodatabase and workgroup instance of ArcSDE. The answer is that enterprise geodatabases are supported by another type of AMI in the cloud. For our test bed project, another AMI meant more money. In addition, the enterprise geodatabase AMI is PostgreSQL based. While the migration process does not involve any magic, it would have required a little more time and effort to get our tabular data in there, so we elected to store static layers in a file geodatabase to guarantee acceptable performance and store editable layers in a workgroup ArcSDE instance running against SQL Server Express on our existing AMI, which was safely under the 4 GB file size limit. There are no tile caches used in this test bed deployment.

Conclusion

The cloud-based deployment available under ArcGIS 10 is sure to present an excellent option to organizations that have wished for more scalability and flexibility in their existing ArcGIS Server infrastructure. Our experience to date has shown us that, for organizations where rapid deployment is critical, ArcGIS Server AMIs can be deployed in approximately 20 minutes (exclusive of the time needed for data and application loading and configuration). The ability to create additional AMIs from an already configured instance, when coupled with the Amazon Load Balancer, means that gaining capacity rapidly when necessary is a real benefit of this new development in the Esri product stack.

This scalability on demand, when viewed against the backdrop of the typical software and hardware procurement process in many organizations, is a very real benefit. Furthermore, the flexibility this provides to organizations, through the capability to deploy this additional capacity on demand—rather than having multiple ArcGIS Servers sit idle awaiting the next emergency response event or natural disaster—reinforces this benefit.

About the Authors

Brian Noyle, originally trained as a global change biologist and tundra botanist, has nearly 10 years of experience as a GIS software developer and architect. His professional and technical interests are primarily focused on moving clients toward more standard architecture and development practices and patterns to facilitate a closer integration of GIS with the standard IT enterprise. Noyle has extensive experience in full software life cycle management with a focus on delivering through Agile project management methods.

Dave Bouwman has been designing and developing GIS software for the last 12 years, with projects ranging from small websites to statewide enterprise forest management systems. Over the last few years, he has been leading a team of developers in the pursuit of great software built in a sane manner. The combination of an Agile process with pragmatic development practices taken from extreme programming has led to a highly optimized methodology of creating solid software.

(Reprinted from the Fall 2010 issue of *ArcUser* magazine)

Case Study

Cloud-Based Routing Software Is What the Doctor Ordered

Home Medical Equipment Company Saves Time and Fuel, Improves Scheduling and Customer Windows

Based in Sunnyvale, Texas, Shalem Medical Supply services a multitude of health care patients, including those who are on hospice and home health, as well as several medical facilities. The company provides durable medical equipment and supplies, with delivery trucks running 24 hours a day, 7 days a week. Shalem employs around 25 people and has three locations: Sunnyvale, Fort Worth, and Houston.

As the company grew and took on new patients, the complexity of getting equipment and supplies delivered in a timely manner had grown next to impossible.

"We were lackluster in efficiency, and it was difficult to maintain accountability," says Zach Paton, operations manager with Shalem. "We had no time frames whatsoever. It presented some very serious challenges."

Shalem realized that it needed to find a vehicle routing and scheduling solution that would help manage daily deliveries.

"We were looking for a software system that you could manipulate in real time and update during the day, and a lot of the systems just didn't offer that," Paton adds.

After a review of several vendors, Shalem chose ArcLogistics, thanks to the solution's cloud-based deployment model, cost, and ability to interface with the inventory management software.

A Competitive Industry

Depending on the day, each Shalem office could have up to 10 vehicles in the field, making anywhere from 15 to 25 deliveries. In a business that is growing due to aging baby boomers and the social acceptance of health care taking place in the home, Shalem realized that its outdated procedures would cost it in the long run if the booming industry continues to see consolidation of smaller home medical equipment providers.

Patients waiting for vital medical aids from Shalem are now provided with tighter time windows.

"In this industry, everybody is looking to get it quick, because we're dealing with a multitude of illnesses and disabilities," says Dennis Morgan, operations manager.

Morgan works with the Shalem dispatchers, monitoring where the drivers are; where they're headed; and the amount of stops and deliveries they have to make that day, including any last-minute additions.

"We may start our day with each driver having 12 stops," he says, "but by the end of the day, there may be 10 to 12 more tickets added to our routes."

Prior to acquiring ArcLogistics, Morgan says the company was constantly rearranging routes and providing very large time windows to customers, which was hurting Shalem competitively. Shalem employees would joke about their time windows being in the realm of, "We'll be there sometime between noon and 7:00 p.m." Since the implementation of ArcLogistics, the routing software has helped reduce time windows to two hours.

At each stop, ArcLogistics Navigator helps drivers reach their destinations according to the streets selected and sequence established in the route plan.

Did the Drivers Revolt?

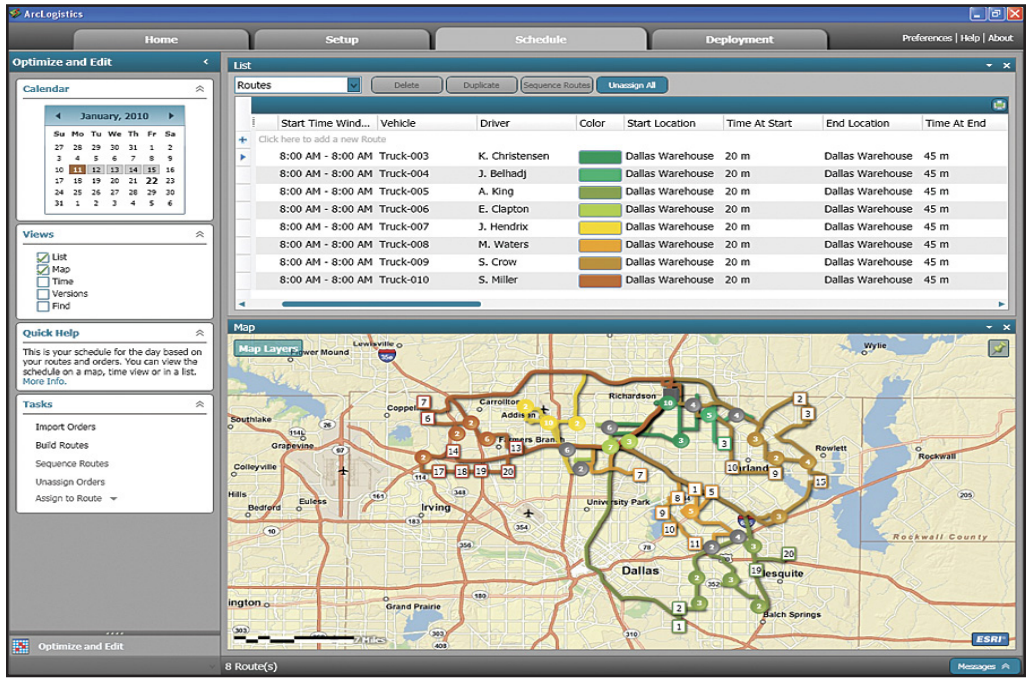
A concern many have when considering routing and scheduling software is whether or not dispatchers and drivers will accept the software. In many cases, these are professionals who have spent years learning their local street networks and customer needs and establishing processes to help get the job done.

Morgan said initially his drivers were against following the plan established by the software. At first, early routes were suggested, then drivers were able to run their routes according to their old ways and compare the two when they got back.

"They were out there three hours longer [with the older routes]. And you can track them and see," Morgan says. He explains that eventually, the drivers came around when they realized the route plans created with ArcLogistics would get them back to base sooner. There were a few drivers who had issues, especially when it came to the touchy subject of overtime. However, Morgan and Shalem came up with a bonus system. The drivers

realized they were driving around 50 fewer miles per day, which began to add up dramatically, resulting in significant cost savings for the company. Morgan would reiterate to the drivers that if they saved on fuel and maintenance, that meant the potential for more money in the employees' pockets, not to mention job security in an unstable economy.

"We've got some mature drivers who have been in the business for a while," says Morgan. "And once you sit down and explain to them, yeah, maybe you're not getting 10 hours overtime, but with the time we're saving, it's going to allow the company to put more money in your pocket and give you a bigger hourly raise or be able to give bonuses."



Route solvers, street data, and imagery are now all accessed via the cloud, making the solution affordable for midsize operations like Shalem.

Immediate ROI

"Our overtime costs dropped by at least 20 or 25 percent. It's decreased our fuel consumption and maintenance costs on the vehicles at least 10 or 15 percent, if not more than that," says Paton, who runs a daily report for the stops made, which includes the mileage that's driven and the fuel costs. Since using ArcLogistics, the first thing he noticed was the big drop in total mileage driven. He estimates a mileage decrease of around 10 percent just in the first week the solution was put in use.

"You will see your money is being recouped right away in maintenance, gas, [employee] hours, and the whole ball of wax. It's something that I would advise anyone that's going into a business where you're going to have multiple vehicles to look into it," Morgan says.

For more information, contact Zach Paton, Shalem Medical Supply (Web: www.shalemmedical.com).

(Reprinted from the Fall 2010 issue of *ArcNews* magazine)

About the Author

Victoria Kouyoumjian is an IT Strategies Architect at Esri focusing on emerging technologies and trends, such as open source, social media, and cloud computing, to name a few. For questions or comments, contact her at vkouyoumjian@esri.com and follow her on Twitter @VKouyoumjian.

Since 1969, Esri has been giving customers around the world the power to think and plan geographically. The market leader in geographic information system (GIS) solutions, Esri software is used in more than 300,000 organizations worldwide including each of the 200 largest cities in the United States, most national governments, more than two-thirds of Fortune 500 companies, and more than 5,000 colleges and universities.

Esri applications, running on more than one million desktops and thousands of Web and enterprise servers, provide the backbone for the world's mapping and spatial analysis. Esri is the only vendor that provides complete technical solutions for desktop, mobile, server, and Internet platforms. Visit us at esri.com.

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